 J Hum Ecol, 32(1): 23-27 (2010)

An Empirical Prediction of Seasonal Rainfall in Nigeria

B.E. Omogbai

Department of Geography and Regional Planning, Ambrose Alli University, Ekpoma, Nigeria

KEYWORDS Surface Temperatures. Outgoing Long Wave Radiation. June-July-August-September Area Rainfall (JJAS)

ABSTRACT The need to have quantitative means of probing anticipated rainfall is essential and inevitable for the purposes of planning and policy formulation. This paper attempts to present some results of an ongoing experiment on empirical prediction of seasonal rainfall in Nigeria. Rainfall in Nigeria is characterized by both latitudinal and longitudinal variations. In the southern part of the country, the seasons could be classified as March, April, May (MAM), April, May, June (AMJ) and June, July, August, September, (JJAS) while the northern area has one rainfall season – June, July, August, September, (JJAS). The June, July, August and September, (JJAS) season is common to both the southern and northern parts of the country. In the formulation of this experiment, it was assumed that there exists an empirical relationship between some physical parameters (atmospheric, geophysical and oceanic) and rainfall. Rainfall data from twenty Nigeria stations, Sea Surface Temperature Anomalies (SSTA) and Outgoing Longwave Radiation (OLR) constituted the input data for formulation of the prediction equations. The rainfall data and SSTA indices spanned from 1950 to 2006 while OLR indces were from 1979 to 2007. Principal Component Analysis (PCA) of the rainfall data divided the country into six homogenous rainfall zones. The six zones were correlated with global SSTA (Reynolds SST) and OLR indices from the Central part of Africa and South Atlantic Ocean. Correlation between the area averaged JJAS rainfall and the predictors ranges from 0.32 to 0.62, which suggests some degree of skill. Forecast for JJAS 2006 rainfall over the regions saw the OLR becoming a better Predictant. These zones of (SWR, SER, NR2 and NR3) performed creditably well from the equation results.

INTRODUCTION

In the recent past, in Africa and Nigeria in particular, the emphasis of many scholars in the study of tropical climatology has been the consideration of rainfall characteristics such as rainfall amount, duration and intensity. The various rainfall characteristics have been studied in terms of their distributions over space and time, trends, periodicities, onset, retreat, probabilities (Ayoade 1974; Ilesanmi 1972a; Ayoade and Akintola 1982; Adejuwon et al. 1990; and Odekunle 1997). The highly variable nature of the rainfall in the region as compared with the relatively stable nature of the temperature, appear to have imbued more relevance to the former as the major component in the study of climate in the region (Adejuwon 1988; Kane 1999; Gbuyiro et al. 2002).

However, as comprehensive as the various research works on rainfall characteristics of the various tropical land area, the literature indicates that little attention has been paid to amount and it's characteristics, most especially, its predictability. Excerpts from the works of Garbutt et al. (1981), Ayoade and Akintola (1982), shows that most studies on tropical rainfall climatology were overly concerned with rainfall amounts rather than it's predictability.

The established concepts of factors which promote or inhibit rainfall precipitation in West Africa and Nigeria in particular is the progression or regression of the zone of influence of the tropical maritime air mass (MT) and it's associated zone of discontinuity.

The Inter-tropical Discontinuity (ITD) is the most popularly accepted medium that influence rainfall distribution in Nigeria (Clackson 1957; Obasi 1956; Mbele-Abong 1974; Ayoade 1988; Ilesanmi 1981; Lamb 1983; Adejuwon et al. 1990). It is established that to the southern part of ITD, varying degrees of convective activity and precipitation takes place, whereas, little or no cloud development or precipitation occur to the northern part. In other words, rain falls mostly when an area is over-lain by the Tropical maritime (mT) air mass and ceases when the area is over lain by the Continental Tropical (cT) air mass. This makes the position of ITD a great determinant of most rainfall attributes in the region. Prominent among these attributes are the length of the rainy season. It, thus, appears as if the ITD is a rain-producing phenomenon in itself, but in reality, weather zones occur in a latitudinal spatial relationship to it (Ilesanmi 1981).

However, a new climatic phenomenon of global influence, the EL Nino/Southern Oscillation is being invoked as a significant cause of rainfall variability over space and time in West Africa (Adedokun 1978; Rasmusson 1985; Burroughs 1992; Kripalani and Kulkani 1997; Kane 2000; Chang 2002). ENSO teleconnection is defined in two ways, namely in association with the Sea-Level Pressure (SLP) and also in association with the Sea Surface Temperature (SST) (Bjerknes 1966, 1969). Today, SST appears to be the most widely accepted parameter, by which ENSO investigated phenomenon produces a number of effects on the nature of rainfall.

It, thus, appears from the literature that rainfall-engendering factors which serve as explanatory factors in the prediction of rainfall distribution in Nigeria include sea surface temperatures of Atlantic Ocean from the Gulf of Guinea, southward up to the Benguella current region of Southern Atlantic Ocean, land/sea thermal contrast between the SST locations and rainfall stations in Nigeria, surface location of ITD and land surface temperature of rainfall stations in Nigeria.

Empirical prediction of seasonal rainfall and the operational uses of such prediction is relatively new in Nigeria. Significant precipitation is recorded April to October in the southern part of the country and from June to September over the northern part. The month of June, July, August and September (JJAS), season is common to both the southern and northern part of the country. According to Elfatih and Cuiling (1996), one of the main seasons in West Africa. Poor rainfall in JJAS can cause considerable stress on maturing crops and other economic activities in Nigeria. It is therefore necessary to predict within acceptable limits of reliability the performance of the season's it rainfall. This paper attempts to establish an Empirical relationship between JJAS rainfall in Nigeria with SSTA and OLR.

Various studies have been carried out on the relationship between rainfall over West Africa and SSTA (Lamb 1978 and Folland et al. 1986). The use of global SSTA to predict seasonal rainfall, especially in the Sahel was also explored by Owen and Ward (1989).

METHODOLOGY

The rainfall database consisting of twenty Nigeria stations having 56 years of monthly rainfall records and covering the period from 1950 to 2006 were obtained from the Meteorological Services Department. Reynold's global SSTA and OLR indices were obtained from NCAR reanalysis data for the periods 1950 to 2006 and 1979 to 2007 respectively. The rainfall data was subjected to principal component analysis, PCA, which produced six homogenous rainfall regions as shown in Figure 1.

Further analysis of the area averaged seasonal rainfall (JJAS) in NRI and NR2 suggested a transfer of Kano rainfall in September to region (NRI).

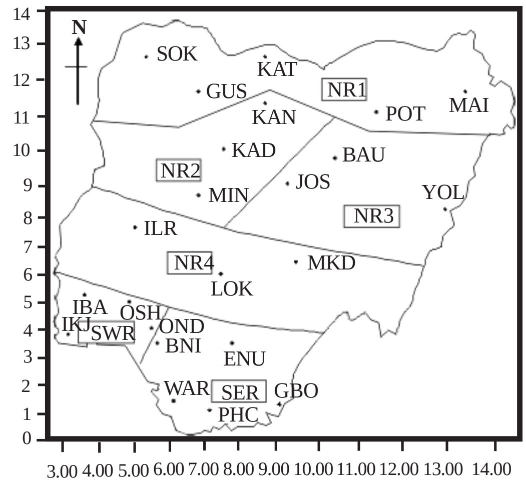

Fig. 1. Nigeria: Location of the homogenous rainfall

The standardized area average indices of the regional JJAS rainfall global ocean SSTA from January to June were correlated. Standardized average SSTA indices of the global ocean regions, which had relatively stronger correlation with the rainfall, were obtained. A linear regression analysis was performed with these indices based on a linear relation of the form.

PP (J) = A + B*X (T).

Was assumes, where

PP = represents the Predicant, which is regional area averaged JJAS rainfall.

J = (I, II, III, IV, V, VI) stands for the rainfall regions, X is the predictor (SSTA/OLR) while T is the period (appropriate month or season area average of the predictor X while A and B are constant. Table contains regional values of A and B corresponding to the better predictor.

RESULTS AND DISCUSSION

The principal component analysis (PCA) divided the country into six homogenous rainfall zones as seen in table 1.

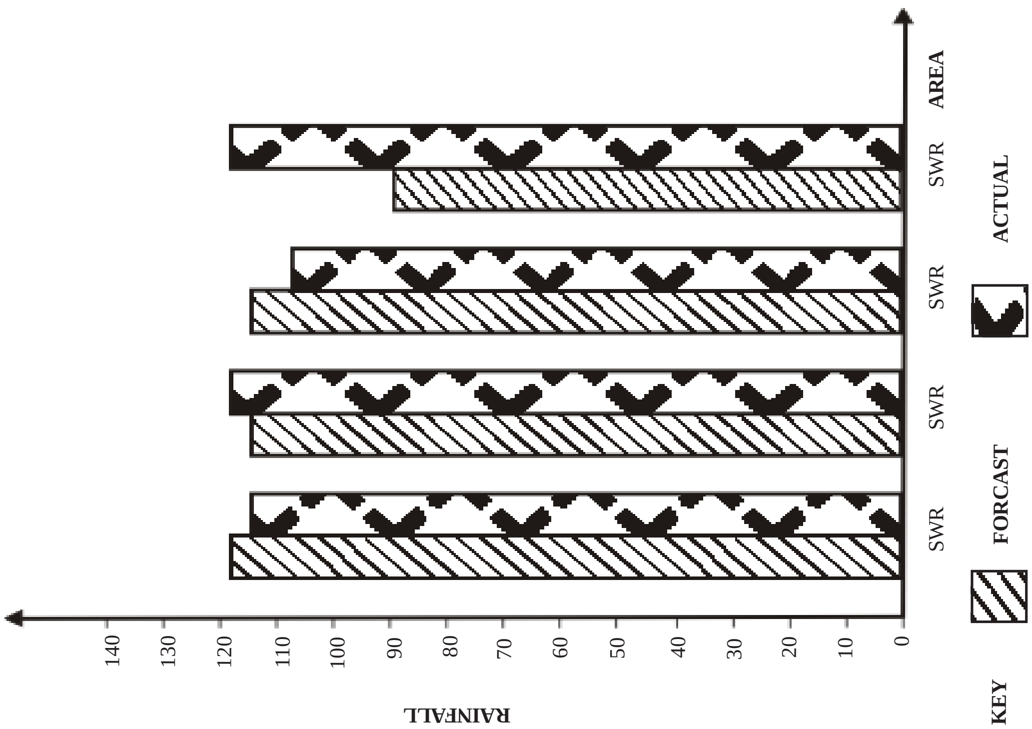

Fig.2. 2006 JJAS area rainfall in percentages (%)

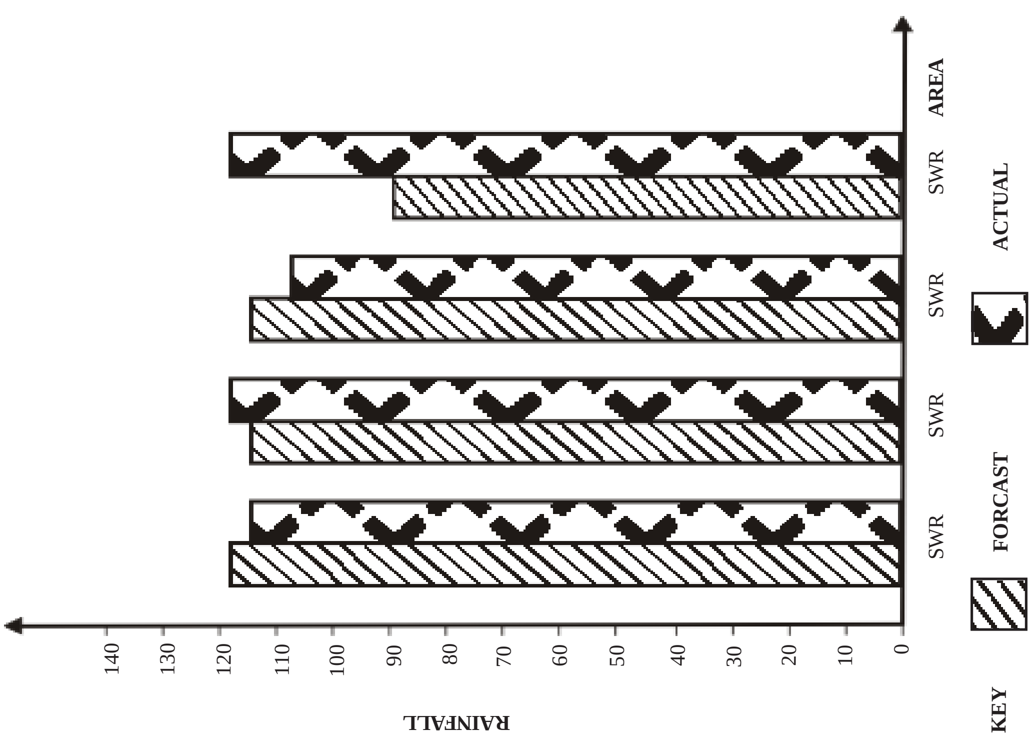

Fig.3. 2006 JJAS area rainfall in percentages (%)

Table 1: The six rainfall homogenous zones

Region	*Indicator*	*Rainfall station*
I	NR1	Sokoto, Kastina, Potiskum, Maiduguri
II	NR2	Minna, Kaduna, Kano.
III	NR3	Jos, Bauchi, Yola
IV	NR4	Markudiri, Lokoja, Ilorin
V	SWR	Oshogbo,
VI	SER	Benin, Enugu, Port-Harcourt, Calabar

NR1 is northern region 1
NR2 is northern region 2
NR3 is northern region 3
NR4 is northern region 4
SWR is southwestern region
SER is southeastern region

Table 2: Results of PCA and the constants obtained

Region	*Indicator*	*A*	*B*	*X*	*T*
I	NR1	0.399	-0.03	SST	May
II	NR2	-0.233	-0.432	OLR	April
III	NR3	-0.60	-0.669	OLR	May
IV	NR4	-0.138	-0.627	SST	May
V	SWR	0.078	0.684	OLR	May
VI	SER	0.119	-0.492	OLR	May

The values of the contents are displayed in table 2.

The values of the constants, A and B, gives rise to a distinctive Empirical prediction scheme for each rainfall region in the country. Comparison of the prediction skills (SWR, SER, NR2, NR3) of the six regions. however, the extreme northern part of the country, (Sokoto, Kastina, Potiskum, Maiduguri – NR1) and places in the southern fringes of the north, (Ilorin, Lokoja, Markudi NR4) are better predicted with global SSTA.

Prediction for 2006 JJAS Season

The prediction equations were applied to forecast the area average for 2006 JJAS with the sole aim of deducing their performance. The verification could only be carried out in rainfall regions where OLR is a better predictor. The comparison chart consisting of the forecast and actual (2006) and the mean (1979 – 2006) JJAS rainfall shows appreciable skill in predicting SWR, SER and NR2 seasonal rainfall. Although the forecast for 2006 JJAS area rainfall over NR3 (84% of mean) was below the actual rainfall in the area, it was within the normal range of ±25% of the mean.

CONCLUSION

A linear relationship was found to exist between sea surface temperature (SSTA) and the rainfall amount. The Outgoing Longwave Radiation (OLR) which constituted the input data for the formulation of the prediction equation performed well.

The correlations between the area average JJAS rainfall and the predictors ranged from 0.32 to 0.62, which suggest some degree of skill. Forecast for JJAS rainfall in 2006 over the region showed that OLR was a good predictor for all regions in Nigeria especially the SWR, SER, NR2 and NR3

ACKNOWLEDGEMENT

My appreciation goes to the staff the library section of the Nigerian Metrological services, the rainfall, surface location of Inter Tropical Discontinuity and land surface temperatures. I am also greatly indebted to the staff on the Hadley centre Meteorological office, London, Bracknell for the provision of the required sea surface temperature data.

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